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ORIGINAL RESEARCH

THE RELATIONSHIP BETWEEN ADHERENCE BEHAVIORS AND RECOVERY TIME IN ADOLESCENTS AFTER A SPORTS-RELATED CONCUSSION: AN OBSERVATIONAL STUDY

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ABSTRACT

Background: Adherence to rehabilitation is widely accepted as vital for recovery and return to play following sports injuries. Medical management of concussion is centered around physical and cognitive rest, a theory largely based on expert opinion, not empirical evidence. Current research on this topic focuses on factors that are predictive of adherence to rehabilitation, but fails to examine if patient adherence leads to a better outcome. The purpose of this study was to determine the adherence tendencies of adolescents to treatment recommendations provided by a sports-medicine physician after a concussion and to determine if adherence to each recommendation was a predictor of treatment duration.

Study Design: Observational.

Methods: Participants were enrolled in the study at their initial visit to the Sports-Medicine Center for medical care after a sports-related concussion. Individual treatment recommendations provided by a sports-medicine physician for concussion were recorded over the course of each participant's care. Once released from medical care, each participant was contacted to complete an online questionnaire to measure self-reported adherence tendencies to each treatment recommendation. Adherence was measured by two constructs: 1) the reported receptivity to the recommendation and 2) the frequency of following the recommendation. Exploratory univariate Poisson regression analyses were used to describe the relationship between adherence behaviors and the number of days of treatment required before the participant was returned to play.

Results: Fifty-six questionnaires were completed, by 30 male and 26 female adolescent athletes. The self-reported adherence tendencies were very high. None of the measures of adherence to the treatment recommendations were significant predictors of the number of days of treatment; however, there was a clear tendency in five of the six rest parameters (physical rest, cognitive rest with restrictions from electronics, and cognitive rest with restrictions from school), where high levels of adherence to rest resulted in an increased average number of days of treatment (slower recovery) and those who reported being less adherent recovered faster.

Conclusions: Adolescents were generally adherent to the physician recommendations. Those participants who reported being less adherent to physical and cognitive rest generally recovered faster than those who reported higher levels of adherence to these recommendations. As time progresses after the initial injury, physical and mental rest may be less effective to hasten recovery than more active treatment recommendations.

Level of evidence: Level 2

Key words: Adherence, adolescent, concussion, recovery, rest

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INTRODUCTION

Concussions are common in athletes who participate in junior high, high school, and college level sports. A concussion is defined as a complex pathophysiological process affecting the brain, induced by biomechanical forces.[1-4] Management of sports-related concussion has become a controversial topic in literature with a variety of organizations producing position statements and recommendations.[5-7] Current attention to this topic is warranted as concussion can cause symptoms that interfere with school, social and family relationships, and participation in sports.[8] Appropriate management of concussion is therefore essential in reducing the risk of long-term symptoms and complications.

The goal of managing student athletes after a concussion is to hasten recovery while ensuring that the athlete is aware of all activities that may slow or hinder this process.[8] Typical instructions and medical management provided to concussed athletes may include mental rest from electronics, mental rest with restrictions from school, physical rest (with restrictions from exercise and sport participation), prescription medication, physical therapy, or referrals to other medical specialists. Despite the medical recommendations provided to athletes, a retrospective study completed in 2009 demonstrated that 40.5% of concussed athletes in the United States were non-compliant with return to play guidelines, returning to contact physical activity without proper medical clearance.[9] Non-adherence to physician recommendations and premature return to play can result in re-injury, more severe post-concussive symptoms, and other potentially devastating brain injuries, such as second-impact syndrome.[9]

In all sports-related injuries, regardless of diagnosis, adherence to rehabilitation is believed to be vital for successful recovery and return to sport.[10] Personal factors including self-motivation, pain tolerance, and athletic identity,[10,11] as well as situational factors including peer support[12] and stress level[11] have been shown to predict adherence to rehabilitation after sports injury. Although these factors predicting positive adherence have been identified, current literature fails to examine if adherence does in fact lead to better outcomes, such as shorter recovery times.

Appropriate medical management of concussion is crucial, but it is unknown if individuals who have sustained a concussion are adherent to the treatment recommendations of sports-medicine physicians. The current research attempts to determine the extent to which student athletes are receptive to each treatment recommendation they receive from their sports-medicine physician after concussion and how frequently they report following each recommendation. A second objective was to determine if the athlete's adherence behaviors were predictors of the number of days that they were under the care of a sports-medicine physician before they are returned to play (days of treatment), the primary outcome of this study.

METHODS

Study Design: This is an observational study of the natural history and recovery after a sports-related concussion utilizing clinical data and data obtained through an online survey.

Ethical review: This study was approved by the Institutional Review Board at Akron Children's Hospital and the Human Subjects Review Board at Walsh University. Informed consent was obtained from the parent or legal guardian as well as an assent from those participants under age 18. Informed consent was obtained from participants who were 18 or older.

Sample: This convenience sample consisted of adolescent athletes (12-19 years of age) who were seen at Akron Children's Hospital Sports-Medicine Center, with a diagnosis of sports-related concussion. Patients were invited to participate if they sustained a concussion during the participation in a sport activity. Motor vehicle accidents or other etiologies for concussion were not included. Adolescents with history of previous concussions were included in this study as well as those with no previous concussions. Athletes were invited to participate in this study regardless of the time that had passed between the concussion and the first office visit to the Sports Medicine Center.

Data collection: The data collected included age, gender, Post-Concussion Score (PCS) at the initial medical appointment, and number of previous concussions. The sport where the concussion occurred and date of the concussive event was collected for each athlete. For each patient, the treatment recommendations that were provided to the patient over their course of care were recorded. This included recommendations for physical and mental rest,

treatment with medication, or referral to physical therapy or another specialist for follow-up care. Finally, the date when the patient was discharged from sports-medicine and returned to full contact play was recorded. In Ohio, a physician signature is required for return to play; thus, the date of recovery from the concussion was based on medical determination.

Following the end of medical care with sports medicine, the participant was contacted by e-mail to ask follow-up questions to measure self-reported adherence tendencies. The qualitative questions asked about receptivity to each treatment recommendation provided during their care at the sports medicine center and the frequency with which each recommendation was followed. These questions were modified from research conducted by Brewer et al that describes the Sport Injury Rehabilitation Adherence Scale (SIRAS).[11] The original scale was derived from adherence literature and is based on clinician report of patient adherence tendencies during a clinical appointment.[11] The modifications made for this research project enabled self-report of known constructs of adherence (i.e. "receptivity" and "frequency of following") to concussion treatment recommendations.

An example of this query for each treatment recommendation is displayed in Figure 1.

Participants were queried in this manner about physical rest, mental rest with restrictions from school, mental rest with restrictions from electronics, recommendations for medication, referral to physical therapy, and referral to another specialist (neurologist, psychologist, or other).

Statistical Analyses: All statistical analyses were completed with Statistical Analysis Software (SAS) 9.3. Descriptive statistics for the sample were calculated. The number of days to assessment was calculated by subtracting the date of the initial appointment with sports-medicine from the date of the concussion. The primary outcome of interest, number of days of treatment, was calculated by subtracting the date of full contact return to play from the date of the initial assessment completed at the Sports Medicine Center. The total number of days to return to play was calculated by adding the days to

After your concussion did the medical staff at the Sports Medicine Center at Akron Children's Hospital recommend PHYSICAL rest (restrictions from sports participation or other physical activity)?

> *Yes*
> *No*

During your recovery period, how receptive were you to the recommendations for PHYSICAL rest?

> *Very unreceptive*
> *Receptive*
> *Neutral*
> *Receptive*
> *Very Receptive*

During your recovery period, how frequently did you follow the recommendations for PHYSICAL rest?

> *Never*
> *Rarely*
> *Sometimes*
> *Most of the Time*
> *Always*

Figure 1.

assessment to the days of treatment, and measures total time the athlete was regarded to have a concussion before full return to play.

For the statistical analysis, each receptivity question was condensed from five categories on the survey down to three categories for the analysis. The responses "very receptive" and "receptive" were made into one category called "receptive" (i.e. open and willing to receive the recommendation) and the categories "very unreceptive" and "unreceptive" were made into one category called "unreceptive" (i.e. unwilling to receive the recommendation). The middle category, "neutral", was unchanged. Each question on the frequency of following the recommendation was also condensed from five categories on the survey down to three categories for the analysis. The responses indicating "always" and "most of the time" were made into one category called "most of the time" and the responses "rarely" and "never" were made into one category called "rarely." The middle category "sometimes" was unchanged.

Because this research was exploratory in nature, univariate Poisson regression analyses were completed, modeling the patient receptivity to each medical recommendation for concussion management and the frequency with which each recommendation was followed, individually. Injury characteristics, including initial post-concussion score, and demographic characteristics were also analyzed in this same manner

to determine if these were significant predictors of the number of days of medical treatment. To control for the violation of the distribution assumption that the variance equals the mean of the predictor, PROC GENMOD with the repeated statement was used in all models to obtain robust standard errors for the Poisson regression coefficients.[13]

After the regression analyses were completed for each potential predictor, the coefficients obtained were placed in the model equation to determine the average number of days of treatment for the three levels of each predictor variable. This is the regression equation that was used to obtain the point estimate for the number of days of treatment for each predictor variable.

$$e^{number\ of\ days\ of\ treatment} = \beta_0 + \beta_1$$

RESULTS

A total of 111 participants were enrolled in the original study, treated at Akron Children's Sports Medicine Center, and sent the final follow-up survey. Fifty-six questionnaires were returned and included in the data analysis for a response rate of 50.45%.

The descriptive statistics for the participants are shown in Table 1. Thirty males and 26 females were included in the study. The mean age of participants was 15 years with a majority being high school athletes. Within the sample, the concussions occurred during participation in a variety of sports, with a majority associated with football, basketball, soccer and other sports activities. Forty-four percent of the participants had at least one prior concussion. The number of days to assessment ranged from 1-89 days with a median value of seven days. The number of days to return to play ranged from 9-212, with a median value of 32.5 days. The number of days of treatment ranged from 2-208 with a median value of 25 days.

Of the medical recommendations provided to the participants, three encompassed rest constructs (physical rest, mental rest with restrictions from electronics, and mental rest with restrictions from school) and three encompassed additional interventions (medication, physical therapy or follow up with another specialist). All (100%) of the participants received recommendations for physical rest

and of those, 40 (71.43%) reported receptivity to the recommendation and 49 (87.5%) reported that they followed the recommendation most of the time. Fifty-two (92.86%) received recommendations for mental rest with restrictions from electronics. Of these, 35 (67.31%) reported receptivity to the recommendation and 40 (76.92%) reported that they followed the recommendation most of the time. Forty-two (92.86%) of the participants received recommendations for mental rest with restrictions from school, 33 (82.93%) reported receptivity to the recommendation and 37 (90.24%) reported that they followed the recommendation most of the time (Table 2).

According to the results for the univariate Poisson regression analyses, none of the variables for measures of adherence to the recommendations for rest were significant predictors of the number of days of treatment. However, for the three recommendations of different types of rest (physical, mental with restrictions from electronics, and mental with restrictions from school) five of the six adherence parameters demonstrated that receptivity to the recommendation and following the recommendation most of the time resulted in an increased average number of days of treatment (slower recovery) and those who reported being unreceptive and rarely following the recommendations recovered faster.

Of those participants who were recommended additional interventions, 21 (38.18%) received recommendations for medication. Eighteen (85.71%) reported receptivity to the recommendation for medication and 19 (90.48%) reported that they followed the recommendation most of the time. Eighteen received recommendations for physical therapy, 13 (76.47%) reported receptivity to physical therapy, and 13 (76.47%) reported that they followed the recommendations from physical therapy most of the time. Nine (16.67%) participants received recommendations for a specialist referral, 8 (88.89%) reported receptivity to the recommendation, and 8 (88.89%) followed the recommendation most of the time (Table 2).

According to the results for the univariate Poisson regression analyses on these additional interventions, none of the measures of adherence to the recommendations for medication, physical therapy, or referral to a specialist were significant predictors of the num-

Table 1. *Descriptive Statistics for Participants*

	Mean(SD)	Median	Range
Continuous variables			
Age	15.15 (1.73)	14.98	12.63 – 19.63
Days to assessment	9.98 (12.66)	7.00	1.00 – 89.00
Days of treatment	37.4 (42.21)	25.00	2.00 – 208.00
Days to return to play	47.3 (44.90)	32.50	9.00 – 212.00
Post Concussion Symptom score at assessment	22.7 (22.00)	15.00	0.00 – 85.00
Categorical variables	***n (%)***		
Gender (male)	30 (53.6)		
Level of competition for sport*			
Middle school	17 (30.91)		
High school	37 (67.27)		
College	1 (1.82)		
Sport where concussion occurred*			
Football	18 (32.73)		
Soccer	8 (14.55)		
Baseball/softball	1 (1.82)		
Hockey	0 (0.00)		
Cheerleading	2 (3.64)		
Basketball	11 (20.00)		
Lacrosse	1 (1.82)		
Volleyball	1 (1.82)		
Wrestling	2 (3.64)		
Swimming	1 (1.82)		
Rugby	1 (1.82)		
Other	9 (16.36)		
History of previous concussions			
0	31 (55.36%)		
1	19 (33.93%)		
2	6 (10.71%)		
Physician recommendations			
Physical Rest	56 (100.00%)		
Mental Rest from Electronics	52 (92.86%)		
Mental Rest with restrictions from School	42 (77.78%)		
Medication Rx	21 (38.18%)		
Physical Therapy	18 (32.73%)		
Specialist Referral	9 (16.67%)		

SD = Standard Deviation; does not add up to 56 because of missing data for one participant

ber of days of treatment. Additionally, there were not enough participants that were recommended these additional interventions to draw inferences on their association with the number of days of treatment.

Additional factors analyzed through univariate regression were gender, total post-concussion score at the initial assessment, number or previous concussions, and level of competition (middle school, high school or college). The Poisson regression results exploring these additional characteristics of the sample in relation to recovery time demonstrated that none of the following predictors were significant predictors of the number of days of treatment: gender (p = 0.21), number of previous concussions (p = 0.68), initial post-concussion scale score (p = 0.24), or level of competition (p = 0.24).

DISCUSSION

There were two primary objectives of this research. The first objective was to determine adherence behaviors of adolescents to treatment recommendations

Table 2. *Univariate Poisson Regression of Adherence Behaviors and Number of Days of Treatment*

Variable	Patient Reported Statistics n, (%)	Regression Estimate (95% CI)	Average Number of Days of Treatment	p-value for Overall Significance
Physical Rest – Receptivity		3.67 (3.31,4.03)		.43
Receptive	40 (71.43)	Reference	39.25	
Neutral	11 (19.64)	-.09 (-.74, .57)	35.87	
Unreceptive	5 (8.93)	-.41 (-.96,.14)	26.05	
Physical Rest – Frequency		3.66 (3.34,4.0)		.29
Most of the Time	49 (87.50)	Reference	38.86	
Sometimes	6 (10.71)	-.39 (-1.0,.22)	26.31	
Rarely	1 (1.79)	.03 (-.29,.35)	40.04	
Mental Rest; Electronics – Receptivity		3.52 (.19, 3.16)		.76
Receptive	35 (67.31)	Reference	33.78	
Neutral	11 (21.15)	-.10 (.33, -.73)	30.57	
Unreceptive	6 (11.54)	-.23 (.31, -.83)	26.84	
Mental Rest: Electronics – Frequency		3.50 (.17, 3.16)		.23
Most of the Time	40 (76.92)	Reference	33.12	
Sometimes	8 (15.38)	-.37 (.24, -.85)	22.87	
Rarely	4 (7.69)	.31 (.36, .40)	45.15	
Mental Rest; No school – Receptivity		3.46 (.13, 3.20)		.80
Receptive	33 (82.93)	Reference	31.82	
Neutral	6 (14.63)	-.10 (.40, -.89)	28.79	
Unreceptive	-	-	-	
Mental Rest; No school – Frequency		3.48 (.13, 3.23)		.09
Most of the Time	37 (90.24)	Reference	32.46	
Sometimes	4 (9.76)	-.79 (.37, -1.51)	14.73	
Rarely	-	-	-	
Medication – Receptivity		3.57 (.15, 3.28)		.24
Receptive	18 (85.71)	Reference	35.52	
Neutral	3 (14.29)	-.37 (.26, -.88)	24.53	
Unreceptive	-	-	-	
Medication – Frequency		3.57 (.14, 3.28)		.47
Most of the Time	19 (90.48)	Reference	35.52	
Sometimes	1 (4.76)	-.17 (.14, -.45)	29.96	
Rarely	1 (4.76)	-1.08 (.14, -1.37)	12.06	
Physical Therapy – Receptivity		3.96 (.16, 3.65)		.40
Receptive	13 (76.47)	Reference	52.46	
Neutral	2 (11.76)	.82 (.56, -.27)	119.10	
Unreceptive	2 (11.76)	-.52 (.24, -1.00)	31.19	
Physical Therapy – Frequency		3.96 (.16, 3.65)		.40
Most of the Time	13 (76.47)	Reference	52.46	
Sometimes	2 (11.76)	.81 (.56, -.27)	117.92	
Rarely	2 (11.76)	-.52 (.24, -1.00)	31.19	
Specialist – Receptivity		3.99 (.18, 3.64)		.30
Receptive	8 (88.89)	Reference	54.05	
Neutral	1 (11.11)	-.62 (.18, .97)	29.08	
Unreceptive	-	-	-	
Specialist – Frequency		4.0 (.18, 3.65)		.29
Most of the Time	8 (88.89)	Reference	54.60	
Sometimes	-	-	-	
Rarely	1 (11.11)	-.78 (.18, -1.12)	25.03	

CI = Confidence Interval; p-value for overall significance indicates if the variable was a significant predictor of the number of days of treatment. Receptivity is a self-reported qualitative measure of the subjects' self-reported willingness or openness to receive the recommendation (rated as "receptive," "neutral" or "unreceptive"); the frequency of following the recommendation was a qualitative measure based on the self-report of how often they were complaint with the recommendation (rated as "most of the time," "sometimes" or "rarely")

after concussion. This was measured through self-reported receptivity to each recommendation they received from their sports-medicine physician and how frequently they reported following each treatment recommendation. In this study, it was demonstrated that for each of the recommendations provided by the sports-medicine physicians, the receptivity and frequency of following each recommendation was very high. Although little is established about the implementation of medical recommendations given to adolescents following a head injury, similar findings have been demonstrated in one of the only studies completed on adherence of adolescents to activity restrictions after concussion. Here, self-report diaries were used to measure physical activity, where at two different time points in the study, it was found that the participants reported 20% and 33% noncompliance, indicating the majority of participants did comply with the activity restrictions.[14]

The second objective of this study was to determine if participants' adherence behaviors to each treatment recommendation are predictors of the number of days of treatment needed to recover from concussion and return to play. Despite the finding that there is no statistically significant relationship between the six examined physician recommendations and the primary outcome (number of days of treatment), a clear tendency was observed in the data indicating fewer days of treatment (faster recovery) when students were less adherent to the recommendations for physical rest, mental rest from electronics, and mental rest with restrictions from school. Other research has demonstrated this apparent iatrogenic effect of recommendations to strict rest. In terms of physical rest, it has been shown that while high intensity physical activity is correlated with an increased total symptom score and low neurocognitive performance, the same is observed for those who were restricted completely from exercise activity.[15] Moderate levels of physical activity have been shown to be safe and provide the best outcome for adolescents recovering from acute or post-acute concussion, specifically in a closely monitored physical therapy program.[15,16,17,18]

Considering the impact of mental rest, findings vary greatly in terms of the relationship between cognitive rest and recovery after concussion. Gibson and colleagues found no statistically significant relationship between mental rest and symptom duration, reporting that those participants who received recommendations for cognitive rest had a longer recovery time,[19] findings comparable to those in the current study. It has also been found that cognitive activity, ranging from complete rest to significant cognitive activity, has similar recovery progression, suggesting that while unrestricted activity may hinder recovery, outright restriction from cognitive activity is not necessary.[20]

Clearly, a gap in the literature exists to base best clinical practice for treating concussion and the effectiveness of these treatment strategies. This forces clinicians to support their treatment recommendations on vague advice such as, "In the absence of evidence-based recommendations, a sensible approach involves the gradual return to school and social activities (prior to contact sport) in a manner that does not result in a significant exacerbation of symptoms."[4] The Zurich consensus statement goes on to propose that the cornerstone of concussion management is physical and cognitive rest until symptoms resolve, but specific treatment protocols in terms of the intensity or actual strictness of the demands related to physical and cognitive rest are not included.[4] In light of this, experts are starting to question the practicality, even suggesting the detriment, of recommending strict physical and mental rest for all adolescents in the absence of supportive research evidence[21], further speculating that a more aggressive and active treatment strategy under the supervision of a licensed physical therapist early in recovery may be of benefit.[17,22,23]

Exercise is considered an essential component of rehabilitation for sports-related injuries, sans concussion. Consensus statements[1-4] and position papers[5-7] all advise rest, but none support recommendations for type, degree, and duration of rest. They agree that adolescents should be "asymptomatic" at each stepwise progression of activity,[1-6] but this poses an even further discrepancy as symptom reporting that occurs at baseline,[24,25] as the result of exercise,[26] with non-head related injury,[27] due to mental health stressors, or from concussion can be quite similar. It has been shown in non-concussed and concussed athletes that symptom scores increased slightly from pre-exercise to immedi-

ately following moderate intensity exercise,[26,28] and that a significant number of high school and collegiate athletes who report no symptoms after injury performed abnormally on neurocognitive testing (ImPACT),[29] leading to the concept of being "asymptomatic" as a contradictory requirement for return to activity.[26,27,28] Given these factors, and as no two concussions present exactly the same, safe resumption of physical activity must be overseen by qualified exercise professionals. Physical therapists can provide essential clinical skill in creating individualized treatment programs based on the patient presentation and response to treatment. Implementing supervised exercise in a sport's physical therapy setting allows adolescents to progress through their recovery safely while being monitored for any adverse reactions to activity.

The following limitations of the present study need to be taken into account. The population studied was a small, convenience sample taken from a single hospital setting and therefore the results may not necessarily be generalizable to a larger population. Adherence behaviors were obtained through a self-report measure, which may not represent the true adherence to the recommendations as self-report can over or under estimate true behavior.[30] It is likely that those participants who completed the electronic survey were the most adherent to the recommendations and therefore, presents a selection bias whereby those who opted to participate in the survey may differ from the non-responders in ways that are immeasurable. Therefore, these findings not be representative of all adolescents with concussion. Secondly, although the primary outcome of interest, number of days of treatment, was determined by medical recovery (as deemed by a sports-medicine physician), this designation was determined at a follow-up appointment with sports-medicine. Because of this requirement, this may not represent the actual date of recovery. It is possible that recovery actually could have been established several days prior to the scheduled medical appointment. This potential delay in determination of recovery would be similar across all participants within this study. Based on this study, it is unknown if the individuals who were less symptomatic, with shorter recovery time were non-adherent for that reason, or if the participants with increased symptomatology, and a longer recovery time were compliant in hopes of improvement. Further research on the predictors of adherent behavior post-concussion and the effects of adherence to physical and cognitive rest needs to be completed to better understand this relationship.

CONCLUSION

For each of the recommendations provided by the sports-medicine physicians to the adolescent participants, the receptivity and frequency of following each recommendation was very high. There were no statistically significant relationships found between adherence tendencies and the number of days of treatment; however, a trend in the data was seen indicating fewer days of treatment when the adolescents were less adherent to the recommendations of physical rest, mental rest from electronics, and mental rest with restrictions from school. These findings are important and can be used in subsequent research aimed at determining optimal treatment recommendations following sports-related concussion. There is a strong need for high-level studies evaluating the effects of rest and activity for concussion management.

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